

15. (Not Currently Amended) The photovoltaic device according to Claim 10, wherein the i-type semiconductor layer has a diffraction intensity of the (220)-plane as measured by X-ray or electron-ray diffraction, which is in a proportion of 50% or more with respect to the total diffraction intensity.

REMARKS

Claims 1-15 are now presented for examination. Claims 1-10 and 12 have been amended to define still more clearly what Applicants regard as their invention. Claims 16-21 have been cancelled without prejudice. The abstract has been amended as to the matter of form pointed out in the Office Action. Claims 1, 4 and 10 are the only independent claims.

Claims 1-18 were rejected under 35 U.S.C. § 112, second paragraph, as indefinite. First, cancellation of Claims 16-21 renders the rejections of those claims moot.

The claims have been carefully reviewed and amended as deemed necessary to ensure that they conform fully to the requirements of Section 112, second paragraph, with special attention to the points raised in the Office Action. It is believed that the rejection under Section 112, second paragraph, has been obviated, and its withdrawal is therefore respectfully requested.

Claims 1-4, 6, 7, 10, 12 and 13 were rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. (U.S. Patent No. 5,571,749). Claims 5, 11, 16 and 19 were rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. and in further view of Yamazaki (U.S. Patent No. 6,028,264) and in view of Yamazaki (U.S.

Patent No. 5,556,794). Claims 8 and 14 were rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. and in further view of Higashikawa (U.S. Patent No. 6,252,158). Claims 9 and 15 were rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. and in further view of Kondo (U.S. Patent No. 6,103,138). Claims 17 and 20 were rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. and in further view Yamazaki '264, Yamazaki '794, and Higashikawa. Claims 18 and 21 were rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuda et al. and in further view Yamazaki '264, Yamazaki '794, and Kondo. Cancellation of Claims 16-21 renders their rejections moot.

Claims 1-21 also were rejected under the judicially-created doctrine of obviousness type double patenting in view of co-pending Application No. 09/865,549. Applicants note that since the rejection is provisional, it is not necessary to respond to this rejection at this time, especially in view of the fact that no Office Action has been received in the '549 application.

The present invention has been accomplished based on a result of the present inventors' studies. As a result of these studies, a material gas containing silicon fluoride and hydrogen and containing oxygen atoms in a concentration of 0.1 ppm to 0.5 ppm based on the silicon atoms is used for forming a silicon-based thin film, as is recited in the independent claims. By virtue of this technique, silicon-based thin films having a high crystallinity and a good crystallinity and oriented in the (220)-direction can be deposited at a high rate (see specification page 5, lines 17-27).

In the Office Action the position is taken that independent Claims 1, 4 and 10 would have been obvious over Matsuda, in spite of the fact that Matsuda "does not

disclose the concentration of Oxygen contained in the material gas,” in view of the assertion in the Office Action that semiconductor-grade SiF₄ gas contains on the order of 20 ppm oxygen. First, the Office Action provides no evidence showing semiconductor-grade SiF₄ gas that contains on the order of 20 ppm oxygen. Applicants are aware that SiF₄ gas containing oxygen on the order of ppb can also be produced. No prior art has been produced by the Examiner showing how large a concentration of oxygen should be used. Such a showing is required, *at a minimum*, to begin to support an obviousness rejection.

Moreover, Claim 1 defines that oxygen atoms are incorporated in the material gas in a concentration of 0.1 ppm to 0.5 ppm based on the concentration of silicon atoms. The claim has nothing to do with existence of a dilute gas. Further, even if SiF₄ gas containing oxygen on the order of 20 ppm could be used, it would be *well out of the range* defined in claim 1. In order to support an obviousness rejection, all of the features, exactly as claimed, must be taught or suggested by the prior art. However, in the Office Action, no teaching or suggestion in the art has been identified for even 20 ppm of Oxygen--itself well out of the claimed range, still less what is actually claimed, namely that oxygen atoms are incorporated in the material gas in a concentration of 0.1 ppm to 0.5 ppm based on the concentration of silicon atoms.

Accordingly, the independent claims are believed clearly patentable over the cited references.


A review of the other art of record has failed to reveal anything which, in Applicants' opinion, would remedy the deficiencies of the art discussed above, as references against the independent claims herein. Those claims are therefore believed patentable over the art of record.

The other claims in this application are each dependent from one or another of the independent claims discussed above and are therefore believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual reconsideration, as the case may be, of the patentability of each on its own merits is respectfully requested.

In view of the foregoing amendments and remarks, Applicants respectfully request favorable reconsideration and early passage to issue of the present application.

Applicants' undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,



Attorney for Applicants
Registration No. 38,586

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
Facsimile: (212) 218-2200

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VERSION WITH MARKINGS SHOWING THE CHANGES MADE TO THE CLAIMS

1. (Amended) A process for forming a [silicon-type] silicon-based thin film by high-frequency plasma chemical vapor deposition, wherein silicon fluoride and hydrogen are contained in a material gas and oxygen atoms are incorporated in the material gas in a concentration of from 0.1 ppm to 0.5 ppm based on [that] a concentration of silicon atoms.

2. (Amended) The process according to Claim 1, wherein the hydrogen in the material gas is fed at a flow rate not lower than [the] a flow rate of the silicon fluoride.

3. (Amended) The process according to Claim 1, wherein the [silicon-type] silicon-based thin film is formed at a pressure of 50 mTorr or higher.

4. (Amended) A [silicon-type] silicon-based thin film formed by high-frequency plasma chemical vapor deposition, the [silicon-type] silicon-based thin film having been formed under conditions that silicon fluoride and hydrogen are contained in a material gas and oxygen atoms are incorporated in the material gas in a concentration of from 0.1 ppm to 0.5 ppm based on [that] a concentration of silicon atoms.

5. (Amended) The [silicon-type] silicon-based thin film according to Claim 4, which contains the oxygen atoms in an amount of from 1.5×10^{18} atoms/cm³ to 5.0×10^{19} atoms/cm³.

6. (Amended) The [silicon-type] silicon-based thin film according to Claim 4, wherein the hydrogen in the material gas has been fed at a flow rate not lower than [the] a flow rate of the silicon fluoride.

7. (Amended) The [silicon-type] silicon-based thin film according to Claim 4, wherein the [silicon-type] silicon-based thin film has been formed at a pressure of 50 mTorr or higher.

8. (Amended) The [silicon-type] silicon-based thin film according to Claim 4, wherein the silicon-type thin film has a Raman scattering intensity due to crystalline component which intensity is at least three times the Raman scattering intensity due to amorphous component.

9. (Amended) The [silicon-type] silicon-based thin film according to Claim 4, wherein the [silicon-type] silicon-based thin film has a diffraction intensity of the (220)-plane as measured by X-ray or electron-ray diffraction, which is in a proportion of 50% or more with respect to the total diffraction intensity.

10. (Amended) A photovoltaic device comprising a substrate and formed thereon a semiconductor layer having at least one set of p-i-n junction, wherein at least one i-type semiconductor layer has been formed by a process for forming a [silicon-type] silicon-based thin film by high-frequency plasma chemical vapor deposition, the i-type semiconductor layer having been formed under conditions that silicon fluoride and hydrogen are contained in a material gas and oxygen atoms are incorporated in the material gas in a concentration of from 0.1 ppm to 0.5 ppm based on [that] a concentration of silicon atoms.

12. (Amended) The photovoltaic device according to Claim 10, wherein the hydrogen in the material gas has been fed at a flow rate not lower than [the] a flow rate of the silicon fluoride.

Claims 16-21 (Cancelled).

VERSION WITH MARKINGS SHOWING CHANGES MADE TO THE ABSTRACT

ABSTRACT OF THE DISCLOSURE

In a process for forming a silicon-based thin film by high-frequency plasma chemical vapor deposition, silicon fluoride and hydrogen are contained in a material gas and oxygen atoms are incorporated in the material gas in a concentration of from 0.1 ppm to 0.5 ppm based on [that of] silicon atoms. [By this process, photovoltaic devices having a good photoelectric conversion efficiency and superior adherence and environmental resistance can be formed at a cost made greatly lower than ever.]

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